

Transfer of influenza from contaminated FFRs to the hands of healthcare workers

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Background

- CDC recommended the use of fit tested disposable N95 respirators for healthcare personnel who were in close contact with patients with suspected or confirmed 2009 H1N1 influenza.
- Filtering facepiece respirators (FFRs) are often discarded after each patient encounter.
- Hospitals reported shortages of FFRs during the 2009 H1N1 pandemic.
- The recently identified H7N9 infections in China have again raised concerns of shortages of N95 FFRs in the event of a pandemic.
- FFR reuse or extended use are two options to assist in maintaining FFR supplies, but virus transfer from contaminated FFRs to the wearer or handler is a concern.

Can FFRs serve as a fomite?

- Previously examined areas of interest.
 - How long can infectious aerosols survive on FFRs?
 - Would FFRs that incorporate antimicrobial technologies inactivate infectious aerosols?
 - Would the use of decontamination methods (UVGI, steam, bleach) allow disposable FFRs to be reused?
- Key knowledge gaps required to assess risks of handling contaminated FFRs.
 1. How contaminated are FFRs in the field?
 2. What is the transfer efficiency of virus from FFRs to the hands of the healthcare worker?

FFRs as fomites?

Fomite fo·mite *n.* –

An inanimate object or substance that is capable of transmitting infectious organisms from one individual to another.



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FFR doffing and transfer of viruses

- FFR fomite hazard could be minimized with use of proper doffing techniques.

SEQUENCE FOR REMOVING PERSONAL PROTECTIVE EQUIPMENT (PPE)

Except for respirator, remove PPE at doorway or in anteroom. Remove respirator after leaving patient room and closing door. Con la en. Quite el.

1. GLOVES

- Outside of gloves is contaminated!
- Grasp outside of glove with opposite gloved hand, peel off
- Hold removed glove in gloved hand
- Slide fingers of ungloved hand under remaining glove at wrist
- Peel glove off over first glove
- Discard gloves in waste container

2. GOGGLES OR FACE SHIELD

- Outside of goggles or face shield is contaminated!
- To remove, handle by headband or ear pieces
- Place in designated receptacle for reprocessing or in waste container

3. GOWN

- Gown front and sleeves are contaminated!
- Untape ties
- Pull away from neck and shoulders, touching inside of gown only
- Turn gown inside out
- Fold or roll into a bundle and discard

4. MASK OR RESPIRATOR

- Front of mask/respirator is contaminated — DO NOT TOUCH!
- Grasp bottom, then top ties or elastics and remove
- Discard in waste container

PERFORM HAND HYGIENE IMMEDIATELY AFTER REMOVING ALL PPE

EFECTÚE LA HIGIENE DE LAS MANOS INMEDIATAMENTE DESPUÉS DE QUITARSE CUALQUIER EQUIPO DE PROTECCIÓN PERSONAL

4. MASK OR RESPIRATOR

- Front of mask/respirator is contaminated — DO NOT TOUCH!
- Grasp bottom, then top ties or elastics and remove
- Discard in waste container

contaminado!

- Para quitárselos, tómelos por la parte de la banda de la cabeza o de las piezas de las orejas
- Colóquelos en el recipiente designado para reprocessar materiales o de materiales de desechos

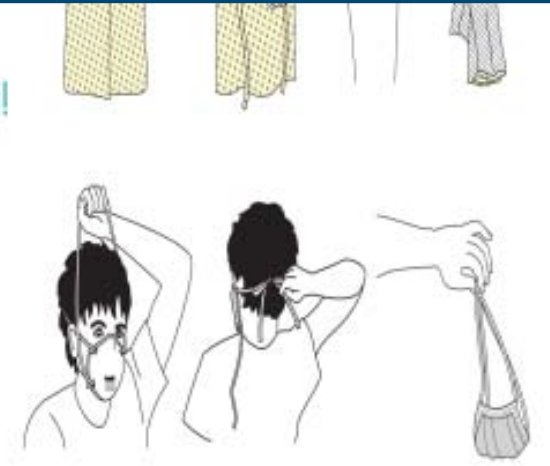
3. BATA

- ¡La parte delantera de la bata y las mangas están contaminadas!
- Desata los cordones
- Tocando solamente el interior de la bata, pásela por encima del cuello y de los hombros
- Voltee la bata al revés
- Dóblela o enróllela y deséchela

4. MÁSCARA O RESPIRADOR

- La parte delantera de la máscara o respirador está contaminada — ¡NO LA TOQUE!
- Primero agarre la parte de abajo, luego los cordones o banda elástica de arriba y por último quite la máscara o respirador
- Arrojela en el recipiente de desechos

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<http://www.cdc.gov/HAI/pdfs/ppe/ppeposter1322.pdf>



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Improper FFR doffing by HCWs

- Data reported at the 2012 NIOSH NPPTL PPT Program Stakeholder Meeting indicates that many HCWs are not using proper FFR doffing techniques.
- HCWs are potentially exposed to infectious organisms when touching the contaminated surface of FFRs.

Respiratory Observation Results of Health Care Workers		
Respirator removed properly (doffing)		
	n	%
Yes	43	62.3
No	26	37.7

Respiratory Protection with PPE of Health Care Workers
Project by Bonnie Rogers, Kathleen Buckheit, Edie Alfano-
Sobsey

Results: N95 respirator demonstration observations (N=39)				
Observation	Yes		No	
	n	%	n	%
Was respirator removed properly (used straps)?	26	67%	13	33%

Respirator Use Evaluation in California Acute Care
Hospitals II by Lauren Joe

<http://www.cdc.gov/niosh/npptl/resources/certpgmspt/meetings/03202012/PresentationsPosters03202012.html>

FFR reuse and extended use

- Potential to transfer infectious agents to hands when redonning and performing user seal check

SEQUENCE FOR DONNING PERSON PROTECTIVE EQUIPMENT (PPE)

The type of PPE used will vary based on the level of precaution required; e.g., Standard and Contact, Droplet or Airborne Infection Isolation.


- 1. GOWN**
 - Fully cover torso from neck to knees, arms to end of wrist, and wrap around the back
 - Fasten in back of neck and waist
- 2. MASK OR RESPIRATOR**
 - Secure ties or elastic bands at middle of head and neck
 - Fit flexible band to nose bridge
 - Fit snug to face and below chin
 - Fit-check respirator
- 3. GOGGLES OR FACE SHIELD**
 - Place over face and eyes and adjust to fit
- 4. GLOVES**
 - Extend to cover wrist of isolation gown

USE SAFE WORK PRACTICES TO PROTECT YOURSELF AND LIMIT THE SPREAD OF CONTAMINATION

- Keep hands away from face
- Limit surfaces touched
- Change gloves when torn or heavily contaminated
- Perform hand hygiene

2. MASK OR RESPIRATOR

- Secure ties or elastic bands at middle of head and neck
- Fit flexible band to nose bridge
- Fit snug to face and below chin
- Fit-check respirator



3. GOGGLES OR FACE SHIELD

- Place over face and eyes and adjust to fit

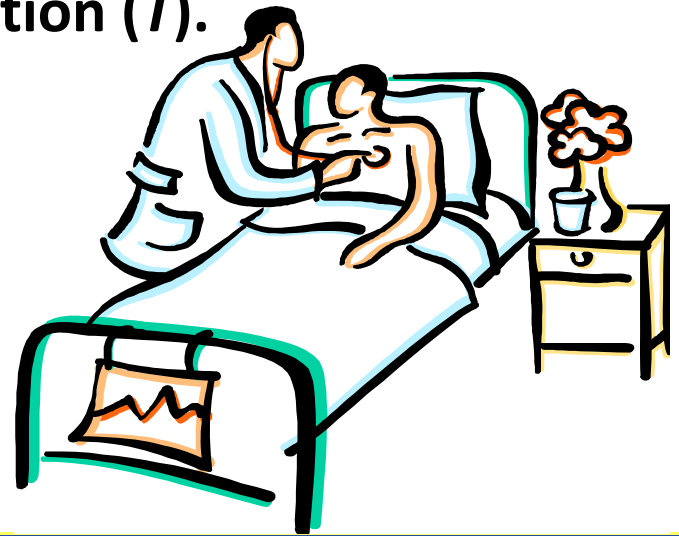
4. GLOVES

- Extend to cover wrist of isolation gown

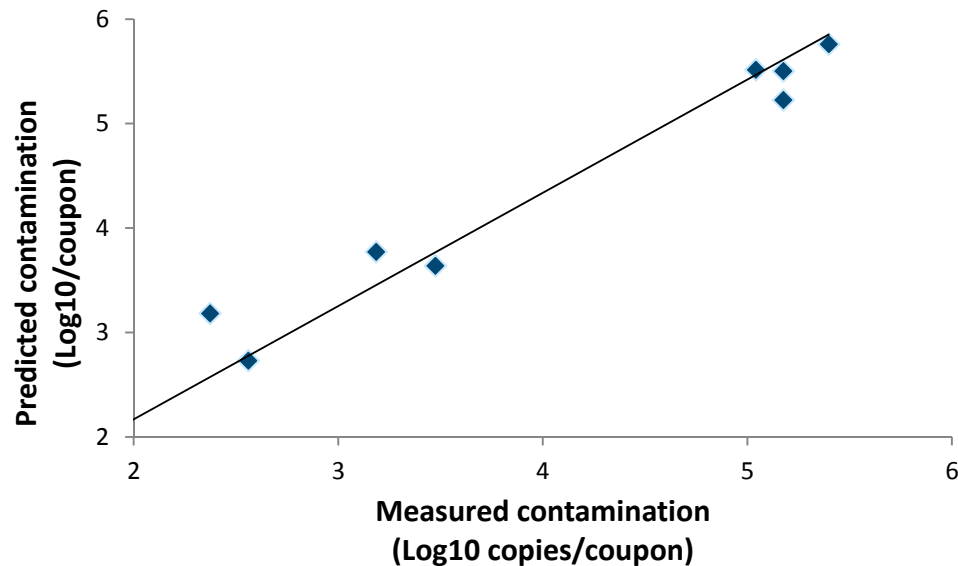
Knowledge gap 1: How contaminated are FFRs in the field?

- A simple mathematical model was developed to estimate the number of viruses trapped on the surface of the FFR
 - The model estimates FFR contamination as a function of:
 - airborne virus concentration (C_v).
 - inhalation rate (IR_a).
 - time of respirator use/patient interaction (T).
 - virus retention FFR (E_r).

$$C_v \times IR_a \times T \times E_r = \text{viruses on mask}$$



Model validation and estimated FFR contamination



Breathing Head Form

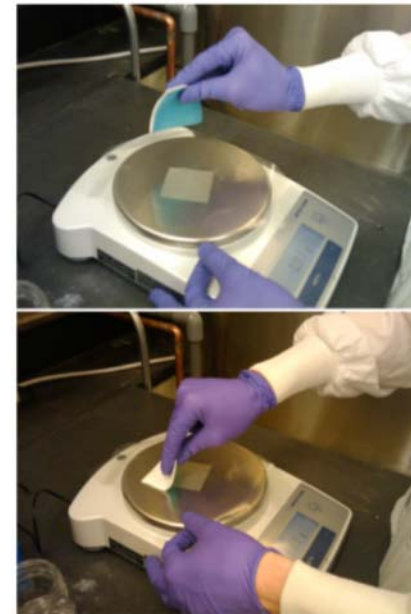
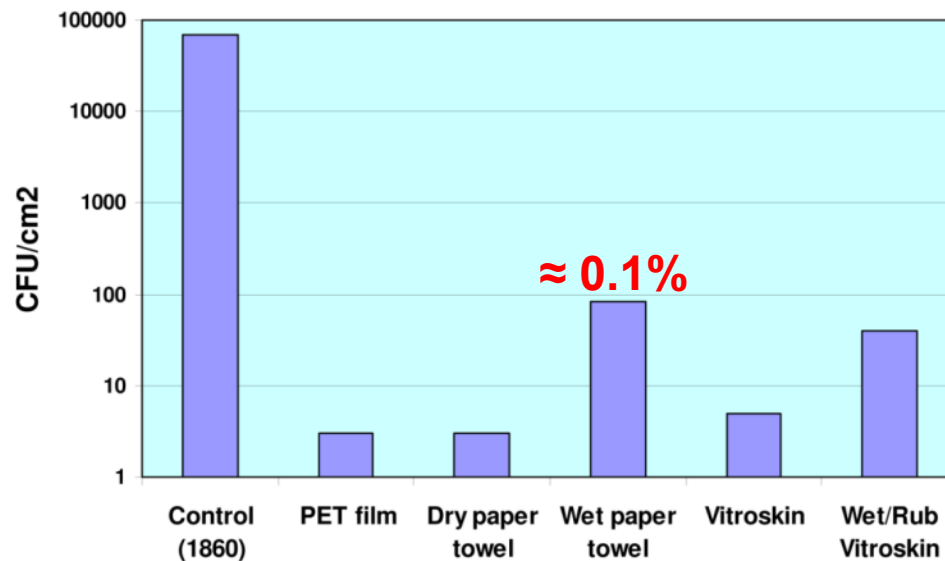
Figure 1. Model validation. Correlation of predicted contamination with measured contamination

Table 1. Model predicted facemask contamination based on inputs from the literature

Facemask Type	Scenario	C _v viruses/m ³	IR _a m ³ /hr	E _r %	T hr	C _a Viruses/mask
FFR	Low value inputs	168	0.780	0.900	0.160	19
	High value inputs	16,000	1.920	0.999	6.600	202,549
	Likely	12,000	1.140	0.991	0.330	4,473
SM	Low value inputs	168	0.780	0.600	0.160	13
	High value inputs	16,000	1.920	0.900	6.600	182,477
	Likely	12,000	1.140	0.770	0.330	3,476

Knowledge gap 2: What is the transfer efficiency of virus from FFRs to the hands of the healthcare worker?

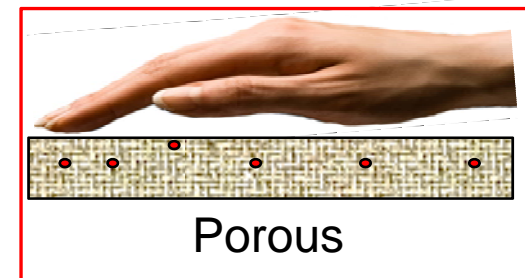
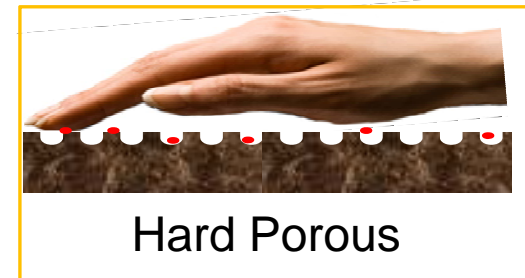
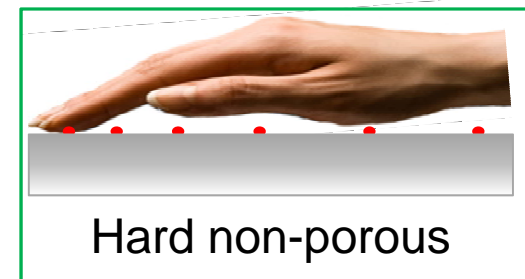
- Respirators contaminated with an aerosol containing *Bacillus atrophaeus*, a Gram+ bacterium.
- Tested transfer of bacteria from FFR to synthetic skin.



Factors that influence microbial transfer efficiency

- Fomites may occur as porous or nonporous surfaces.
- Porous surfaces demonstrate lower transfer rates than nonporous surfaces.

Substrate	% transferred
Lego	65
Vinyl	66
Ceramic	55
Wood	17
Shoulder pad	<1
Towel	<1
Bed sheet	<1



Desai et al. American Journal of Infection Control April 2011

Bacteria vs. virus transfer efficiency

- ***Micrococcus luteus* is a Gram+ bacterium.**
- **PRD-1 is a virus (bacteriophage).**

Table 1 Results from fomite-to-hand transfer (Evaluation Period A)*

P. RUSIN ET AL. *Journal of Applied Microbiology*, **93**, 585–592

Organism/Type of fomite	Mean log ₁₀ CFU or PFU		Transfer efficiency (%)‡
	Level in/on fomite†	Level recovered from ventral surface of hands	
<i>Micrococcus luteus</i>			
Laundry – 100% cotton	9.73	6.17	0.13
Laundry – 50 : 50 cotton/polyester	9.39	5.99	0.06
PRD-1			
Laundry – 100% cotton	8.73	3.63	<0.01 (0.005)
Laundry – 50 : 50 cotton/polyester	8.34	2.71	<0.01 (0.0005)



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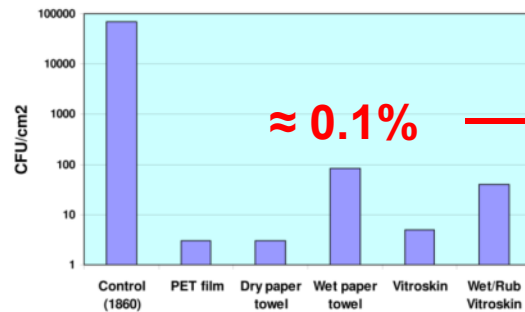
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Estimation of total virus transfer from FFR to hands

Knowledge gap 1: How contaminated are FFRs in the field?

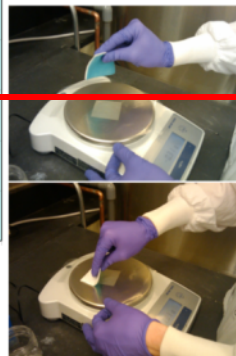
Facemask Type	Scenario	C _v viruses/m ³	IR _a m ³ /hr	E _r %	T hr	C _a Viruses/mask
FFR	Likely	12,000	1.140	0.991	0.330	4,473

Knowledge gap 2: What is the transfer efficiency of viruses from FFRs to the hands?



Vitro skin is artificial skin product widely used in the cosmetics industry.

➤ No significant bacteria transfer. Worst case: 1 in 1000 will transfer.



$$4.3 \text{ viruses transferred} = 4,473 \times 0.1\%$$

Estimation of virus transfer per touch

- Finger tip surface area related to FFR surface area.
- Sum of all fingertip surface areas = 3672 mm².
- For both hands the surface area of the fingertips is roughly 7.34 cm².
- The surface area of the mask is roughly 175 cm².

936 Murai et al. / Volume and Surface Area of the Fingertip

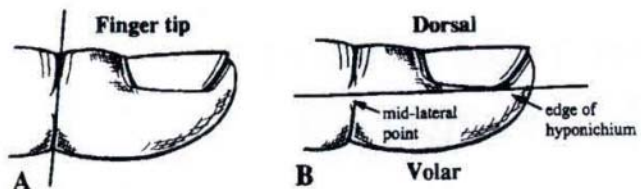


Table 4. Fractional Surface Area* of the Fingertip (mm²)

Fingertip	Surface Area of Volar Part	Surface Area of Dorsal Part	Total Surface Area
Thumb (n = 8)	1070 ± 131 (58)	775 ± 41 (42)	1845 ± 131
Index (n = 7)	666 ± 55 (56)	518 ± 55 (44)	1183 ± 97
Middle (n = 6)	716 ± 32 (55)	580 ± 61 (45)	1296 ± 75
Ring (n = 7)	671 ± 62 (57)	513 ± 38 (43)	1184 ± 98
Little (n = 7)	549 ± 64 (56)	423 ± 36 (44)	971 ± 87

* Mean ± SD.

0.18 virus/ touch \approx 4373 viruses \times 0.1% \times (7.34 cm²/175 cm²)

Other factors to consider for risk analysis when handling contaminated FFRs

- Transfer efficiency of virus from fingertips through points of entry (mouth, nose, eyes) and to points of infection.
- Virus infectivity.

Conclusions

- FFRs could become contaminated with significant amounts of viruses even during short patient encounters (for instance, especially during flu season)
- Based on the model very little contamination should get transferred to hands.

Chief Limitations

- ***"All models are wrong, but some are useful."*** -Statistician George Box.
- **The model may overestimate the transfer of virus to hands of the wearer**
 - Model transfer efficiency for FFRs was conducted using a bacterium and not a virus.
 - Assumes all viruses are infectious.
- **Direct cough or sneeze contamination of an FFR, which may increase the virus count, was not considered.**
- **Others**

Current and future studies

- **Why Hospital Staff Catch the Flu: Assessing modes of transmission**
 - During the 2012/13 influenza season we collected aerosol samples from patient care rooms and surgical masks worn by HCWs within those rooms to determine the level of aerosol and SM contamination.
 - Conduct studies to determine the transfer efficiency of virus (bacteriophage MS2), from contaminated FFRs to the hands of test subjects FY14.

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